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Effect of bio-fertilizers in combination with reduced dose of fertilizers on growth and yield of garlic at high altitude of north-west Himalayas

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ABSTRACT

An experiment was conducted during rabi season of 2006 and 2007 to find out the response of garlic to the application of nitrogen fixing and phosphate solublizing biofertilizers in different combinations with reduced dose of fertilizer (RDF) in various combinations. The treatments included various combinations of *Azotobacter sp., Azospirillum sp.* and *Microphos sp.* in combination with 0%, 50% and 100% RDF. The effects of these treatments were observed at different magnitudes on various growth, yield and yield attributing characters. The growth characters in respect of plant height were found maximum in the plants receiving *Azospirillum sp.* + ½ NP and full K. The neck thickness was observed more in treatment comprised of *Azospirillum sp.* + *Microphos sp.* + ½ NP and full K. Bulb yield and bulb weight was maximum in treatment having *Azotobacter* sp.+ *Azospirillum sp.* + *Microphos sp.* + ½ NP and full K; however, it was on a par with *Azospirillum sp.* + *Microphos sp.* + ½ NP and full K treatment. The same set of nutrient management treatments was also found superior than other treatments in respect of dry matter of the bulb. Differences were not significant among the treatment with respect to horizontal diameter of bulb, number of clove per bulb and clove thickness. Thus, the treatment *Azospirillum sp.* + *Microphos sp.* + ½ NP and full K was found superior for better yield and yield attributing characters as well growth of the plants.

Key words: *Azotobacter* sp., *Azospirillum* sp., *Microphos* sp., garlic.

INTRODUCTION

Garlic (*Allium sativum* L.) is the second most important *Allium sp.* after onion which is extensively used as spices and condiments. India is the second largest producer of garlic after China (Anonymous, 1). The major garlic growing states are Madhya Pradesh, Gujarat, Maharashtra, Haryana, Uttar Pradesh, and Orissa where short day types (small clove varieties) are widely grown. However, in the hilly states like Uttarakhand, Himachal Pradesh, J&K and some North-Eastern States, mainly long day types of garlic is grown which produce the bigger cloves. The short day type garlic can be grown both in hills and plains but long day types do not produce bulbs in the plains. The use of chemical fertilizer help in achieving maximum yield of garlic but keeping present scenario of sustainability and soil health in view, there is an urgent need to enhance the productivity of garlic through supplementation of nutrient requirement through biofertilizers. The chemical fertilizers pose health hazards and reduce microbial population in soil; besides being quite expensive and thereby making the cost of production high. Under such circumstances, biofertilizers may play a major role (Tiwary *et al*., 14). Such eco-friendly integrated approach has great potential for the hilly states like Uttarakhand where approaches such as use of biofertilizers have gained popularity among the farmers in the recent years. The biofertilizers such as *Azotobacter sp.*, *Azospirillum sp.* and *Miccrophos* increase the availability of nutrient and thereby reduce the fertilizer requirements which ultimately results in reduction of cost of production. Application of biofertilizer showed increase in yield and quality by various researchers, but the effect of these biofertilizers on crop plants is enormously influenced by the agro-climatic conditions. The information on these aspects is meagre for high altitude. Hence, the present study was under taken to explore the effect of different biofertilizers and reduced dose of fertilizer (RDF) on growth and yield of garlic under Kumaon hill conditions of Uttarakhand.

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MATERIALS AND METHODS

The experiment was conducted at experimental farm of Central Institute of Temperate Horticulture, Regional Station, Mukteshwar, Uttarakhand (India), situated at 29°N latitude, 79° E longitude and at an elevation of 2200 m above mean sea level during successive seasons of 2006 and 2007. The aim of this study was to investigate the effect of three biofertilizers individually or in combinations with modified dose of Nitrogen (N), Phosphorus (P) and Potash (K) on growth and yield parameters of garlic genotype Mukteshwar Garlic Selection-2. The details of the treatments are given in Table 1.

Table 1. Details of the treatments used for the study.

Treatment No.		Treatment details
T_1	:	Full recommended dose* of NPK
T_2	:	*Azotobacter* + ½ NP and full K
T_3	:	Azospirillum + ½ NP and full K
T_4	:	Microphos + ½ NP and full K
T_5	:	*Azotobacter* + Azospirillum + ½ NP and full K
T_6	:	*Azotobacter* + Microphos + ½ NP and full K
T_7	:	Azospirillum + Microphos + ½ NP and full K
T_8	:	*Azotobacter* + Azospirillum + Microphos + ½ NP and full K
T_9	:	*Azotobacter* + Azospirillum + Microphos + No NPK

*80 g Urea (40 before planting and 40 g 30 days after planting) + 60 g SSP + 30 g MOP per plot (1.5 m^2) before planting; biofertilizers (@10 g) were mixed with 5 kg (per plot of 1.5 m^2 size) of FYM

Three biofertilizers, namely, *Azotobacter sp., Azospirillum sp.* (N_2 fixing) and *Microphos sp* (phosphate solublizer) were procured from Division of Microbiology, Indian Agricultural Research Institute, New Delhi. The plots size was 1.5 m^2 (1.50 x 1.00 m). The land was well prepared and organic manures were added to each bed at the rate of 5 kg/bed before sowing. The treatments were applied as per treatment combinations (Table 1). Biofertilizers were inoculated @ 10 g inoculants along with FYM @ 5 kg per bed as per treatment and cloves were also dipped for 5 minutes in jaggery solution (10 %) containing 5 g of inoculants. The layout of the experiment was Randomized Block Design. The data were recorded as per the descriptor developed by NBPGR (Srivastava *et al.,* 11) and pooled data were analyzed in SPSS-10 software. Results exhibiting significant differences were subjected to DMR test for comparison of their means (Steel and Torrie, 12).

RESULTS AND DISCUSSION

Significant difference was recorded among the treatments with respect to plant height. Maximum height (56.60 cm) was recorded in the treatment having *Azospirillum* and ½ NP and full K (T_3), however, it was at par with the treatment having all the three microorganisms *i.e. Azotobacter*, *Azospirillum sp.* and *Microphos sp.* along with ½ NP and full K *i.e.* T_3 (Fig. 1). The result indicated that *Azospirillum* has greater role in increasing plant height. Kore *et al*. (7) also reported maximum plant height in the treatment containing both nitrogen fixing (*Azotobacter*) and phosphate solublizing bacteria (PSB). This observation in the present study can be further substantiated by findings of Gaiki *et al.* (3) where they reported that the treatment with Azotobacter (AZT) + PSB +75% RDF significantly increased plant height, leaf number, bulb diameter, clove number/bulb, fresh bulb weight, cured bulb weight and yield/ha. Similar results were also reported in maize and wheat plants, where

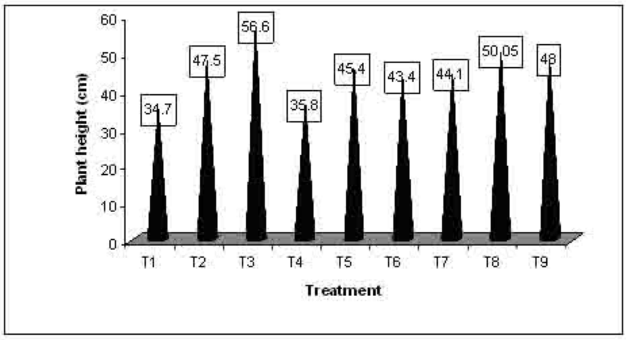

Fig. 1. Plant height as affected by various treatments (LSD $_{0.05}$= 8.02)

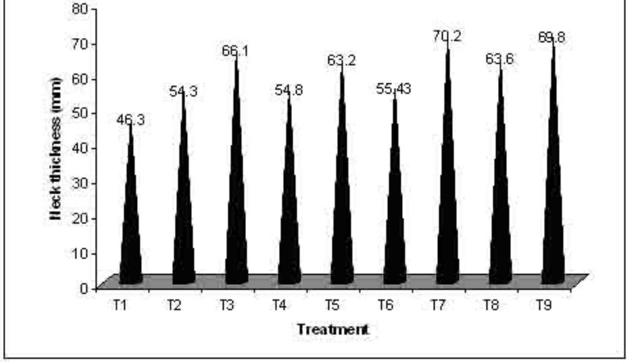

Fig. 2. Neck thickness of the plants under different nutrient management practices (LSD $_{0.05}$= 19. 20)

the inoculation with *Azospirillum sp.* along with synthetic fertilizers mostly increased the height of shoots (Rousta *et al*., 9). *Azotobacter sp.* and *Azospirillum sp.* both are N_2 fixing bacteria, which in the plant rhizosphere have the ability to synthesize and secrete some biologically active substances like vitamin B complex, heteroauxins, gibberellins *etc.,* resulting in promotion of plant growth (Kader, 6). Although difference among the treatments was not significant, maximum number of leaves (14.00) was recorded in treatment which contained all the three biofertilizers (T_8) along with chemical fertilizers while minimum number of leaves were recorded where no chemical fertilizers were used (T_9). However, Chandrasekhar *et. al.* (2) reported maximum number of leaves per plant in treatment comprising *Azospirillum sp.* along with 100 per cent urea. Presence of more number of leaves per plant is important because the leaves are the structures which are photosynthetic machinery and an increase in leaf area may promote root development, better translocation of water uptake and nutrient (Jeevajyothi *et al.*, 4).

Biofertilizers played an important role in early sprouting of clove. The earliest sprouting (5.2 days) was recorded in treatment containing all the three biofertilizers *viz., Azotobacter sp., Azospirillum sp.* and *Microphos sp.* with no chemical fertilizer (T_9). However, this treatment was on a par with treatment containing *Azotobacter sp., Azospirillum sp.* along with half dose of NP and full dose of K. Sprouting was delayed when no biofertilizers were used. *Azotobacter sp.* and *Azospirillum sp.* are known to produce plant growth regulating substances such as IAA, GA_3 and Cytokinin (Tien *et al.*, 13 and Tiwary *et. al.*, 14) which might have promoted early sprouting of clove in the present investigation.

Days taken to attain harvest maturity were significantly influenced by application of biofertilizers. The maturity was earliest (185.20 days) in treatment containing *Azotobacter sp.*, *Azospirillum sp.* and microphos with half dose of NP and full dose of K. and was at par with the treatment containing only *Azotobacter sp.* and *Azospirillum sp.* along with half dose of NP and full dose of K. The maximum period for maturity was taken by the treatment with full dose of NPK. The early maturity in biofertilizer treated plants may be due to high accumulation of dry matter in bulbs because of the augmented uptake of nitrogen, phosphorus and potassium (Yassri and Patwardhan, 16).

Of the different combination tried, treatments T_3, T_7 and T_9 showed significant difference as compared to treatment having recommended dose of NPK. The maximum neck thickness (70.2 mm) was recorded in the treatment containing *Azospirillum sp.* + *Microphos sp.* + ½ NP and full K (T_7). According to Duncan test only two subsets were found; the first comprising T_1, T_2, T_3, T_4, T_5, T_6, and the second constituted T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9. The only significant difference was

Table 2. Effect of different treatments on plant and bulb characteristics.

Treat. No.	Treatment details	No. of leaves per plant	Days to 50 % sprouting	Maturity (days after sowing)	Horizontal diameter of bulb (mm)	Vertical diameter of bulb (mm)	Average bulb weight (g)	Yield (g/plot of 1.5 m^2 size)
T_1	Full recommended dose* of NPK	13.40	7.50	210.20	32.505	24.690 ^{A1}	15.70 ^{CD}	1416.00^{CD}
T_2	*Azotobacter* + ½ NP and full K	12.54	6.20	200.00	33.515	29.335 ^{AB}	14.40 ^{B}	1213.00^{B}
T_3	Azospirillum + ½ NP and full K	12.90	6.70	202.35	36.770	30.685 ^{AB}	14.10 $^{B D}$	1262.00^{BD}
T_4	Microphos + ½ NP and full K	11.89	6.90	208.00	33.970	26.210 ^{AB}	9.95 ^{A}	906.00^{A}
T_5	*Azotobacter* + Azospirillum + ½ NP and full	13.00	5.20	190.00	37.345	32.370 ^{AB}	12.50 $^{A B}$	1052.00^{AB}
T_6	*Azotobacter* + Microphos + ½ NP and full K	13.25	5.60	207.80	36.100	32.785^{B}	11.60 ^{ABC}	1284.00^{ABC}
T_7	Azospirillum + Microphos + ½ NP and full K	13.10	5.80	205.20	36.240	31.765 ^{AB}	16.60 ^{CD}	1304.00^{CD}
T_8	*Azotobacter* + Azospirillum + Microphos + ½ NP and full K	14.00	5.50	185.20	37.390	32.110 ^{AB}	22.85 ^{C}	1517.00^{C}
T_9	*Azotobacter* + Azospirillum + Microphos + No NPK	12.00	5.20	208.56	36.320 NS	31.640 ^{AB}	14.00 ^{B}	1234.00^{B}

[1]Mean separation within columns by Duncan's multiple range test at $P < 0.05$.

Table 3. Influence of various treatments on plant and clove characteristics.

Treat. No.	Treatment details	Dry matter (%)	No. of clove / bulb	Clove length (mm)	Clove width (mm)	Average clove wt. (g)
T_1	Full recommended dose* of NPK	53.900 ^{C1}	12.7 ^{A}	23.57 ^{A}	12.28	0.945 ^{A}
T_2	*Azotobacter* + ½ NP and full K	57.840 ^{AB}	9.30 ^{A}	25.22 ^{ABC}	14.01	1.235 ^{ABC}
T_3	Azospirillum + ½ NP and full K	58.810 ^{AB}	10.40 ^{A}	29.50 ^{BCD}	11.52	1.540 ^{BC}
T_4	Microphos + ½ NP and full K	59.065 ^{AB}	10.80 ^{A}	23.95 ^{AB}	12.35	0.890 ^{AB}
T_5	*Azotobacter* + Azospirillum + ½ NP and full	56.450 ^{AB}	11.50 ^{A}	28.04 ^{ABCD}	13.06	1.220 ^{ABC}
T_6	*Azotobacter* + Microphos + ½ NP and full K	57.125 ^{AB}	10.00 ^{A}	30.09 ^{CD}	14.73	1.475 ^{ABC}
T_7	Azospirillum + Microphos + ½ NP and full K	55.260 ^{A}	10.60 ^{A}	29.91 ^{CD}	13.26	1.595 ^{C}
T_8	*Azotobacter* + Azospirillum + Microphos + ½ NP and full K	63.750 ^{B}	13.10 ^{A}	34.58 ^{D}	14.08	0.995 ^{ABC}
T_9	*Azotobacter* + Azospirillum + Microphos + No NPK	57.640 ^{AB}	11.20 ^{A} NS	32.09 ^{D}	12.28 NS	1.395 ^{ABC}

[1]Mean separation within columns by Duncan's multiple range test at $P < 0.05$.

recorded between treatment T_1 and T_3, T_1 and T_7, T_1 and T_9.

No significant difference was recorded between the treatments with respect to horizontal diameter of bulb, however, it was found significant with respect to vertical diameter. Treatment T_6 showed the maximum vertical diameter while minimum was recorded in treatment T_1.

The treatment T-8 produced maximum bulb weight (22.85g) which was significantly higher from the other treatments except from treatment T_3, T_6 and T_7. The bulb weight was lowest in treatment T_4. No significant difference was recorded among the treatment with respect to the clove number per bulb.

Differences between treatments were significant with regards to dry matter content of bulb. The treatment T_8 registered significantly higher dry matter production than other treatment. The treatment comprising biofertilizers showed improvement in dry matter over untreated one which might be possible due to more nutrient uptake, physiological and biological activities as a result of microbial activities in rhizosphere. The higher dry matter by inoculated plants might be because of the augmented uptake of nitrogen, phosphorous and potassium (Yasari and Patwardhan, 16)

Maximum clove length (34.58 mm) was produced by the treatment T-8, which was at par with treatment T_3, T_5, T_6, T_7 and T_9. Minimum clove length was recorded with treatment T_1, however, no significant difference was found among the treatments with regards to clove width. Average clove weight was maximum in treatment T_7 and minimum in treatment T_4.

The treatment T_8 which contained both *Azotobacter* and *Azospirillum sp.* as nitrogen fixing bacteria, phosphate solublizing bacteria (*Microphos sp.*) and 50 % RDF gave highest yield. But it was found at par with the treatment of full dose of NPK (T_1), T_6 and T_7. It is clear from the above findings that both *Azotobacter* and *Azospirillum sp.* with *Microphos sp.* are equally effective in increasing yield of garlic. *Azospirillum* has also been reported to increase the yield of onion bulb (Yadav *et al.*, 15). Although higher yield was obtained when both the nitrogen fixing bacteria were used (T8) but it was not significant. Further, half dose of nitrogen and phosphorus may be substituted by using nitrogen fixing along with phosphate solublizing bacteria as biofertilizer. The inoculation of plant growth promoting *Rhizobacteria* and VAM could meet almost 50% nitrogen and phosphorus demand of onion crop (Jha *et al.,* 5). This increase in yield may be attributed to higher fixation of nitrogen in soil by biofertilizer and better uptake of nitrogen and phosphorus because biofertilizers are capable of mobilizing nutrient elements from non-usable form to usable form through biological processes (Tien *et al.*, 13). Similar trend was recorded for bulb weight too. This may be due to fact the bulb weight is positively correlated with the yield (Lokhande and Pawar, 8; Singh, 10)

The present investigation highlights the importance of integrated approach of nutrient management using biofertilizers along with reduced dose of chemical fertilizers for sustainable production of garlic under high altitude of NW Himalayas. The use of biofertilizers not only help improving soil health but also increase the availability of N, P and K which are in unavailable form in soil, thereby increasing growth and yield of crop. Furthermore, reduced dose of chemical fertilizers would reduce the cost of production.

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